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Title:	Sampling and Analysis Plan (SAP) for Assessment of LANL-Derived Residual Radionuclides in soils within Tract A-5-3 for Land Transfer Decisions
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Sampling and Analysis Plan (SAP) for Assessment of LANL-Derived Residual Radionuclides in soils within Tract A-5-3 for Land Transfer Decisions

February 2013

1.0 Background for A-5-3

1.1 Site Location

The A-5-3 Tract is located just west of the eastern boundary of DP Mesa, Technical Area-21 (TA-21) and south of Highway 502 (Figure 1). The tract consists of the DP Canyon portion of the "Airport Tract" (DOE 1999). This tract contains undeveloped hillslope and canyon bottom accessed from DP Road. Vegetation includes ponderosa and piñon-juniper woodlands with open shrub, grasslands, and wildflower areas; A-5-3 is considered potentially sensitive wildlife habitat. DP Canyon has an ephemeral stream and receives runoff from surrounding mesas and areas.

This approximately 16-acre tract is located south of Los Alamos County (LAC) Airport (transferred from DOE to LAC in October 2008) and other variously owned County land and private properties. Figure 1 shows the boundaries for Tract A-5-3.

1.2 General History

Historical maps from the pre-LANL era (1924), aerial photographs (1935), and historical accounts of life in the area show little development prior to LANL occupancy (pre World War II). Detroit businessman Ashley Pond started the "Los Alamos Ranch School" in 1917. The school began with a few ranch buildings from the Harold H. Brook homestead.

Laboratory operations began on nearby DP Mesa, just west of Tract A-5-3, in the late 1940s. Plutonium processing operations were conducted on DP Mesa in Tract A-16 or in the technical area TA-21. Additionally, waste disposal operations were conducted at what is now designated Material Disposal Area B (MDA B) on the mesa-top in the western portion of Tract A-16. Tract A-10 has remained vacant throughout except for a well-drilling site.

There are no Potential Release Sites (PRSs) located on the A-5-3 tract, but there are several PRSs that are associated with the historical Laboratory operations on adjacent lands.

1.3 Current Use

Tract A-5-3 is unoccupied, vacant land, with the exception of a groundwater monitoring well. No structures or facilities associated with LANL's federal, state, or local permits (such as air monitoring stations, radiation monitoring stations, or wastewater discharge outfalls) are located within A-5-3. This tract was never actively used by the Laboratory, no Laboratory operations were conducted within the tract boundaries, and no Laboratory structures were situated within the tract.

1.4 Summary of Historical Evaluation of LANL Impact

There are records of radioactive materials being spilled into the canyon bottom (Cs-137 and Sr-90 and Am-241) and air fall from historical operations at TA-21, southeast of this tract, and stack emissions from TA-1 may have resulted in surface deposition of radionuclides, particularly plutonium (LANL 2004).

Tract A-5-3 does not meet the CERCLA 120(h) "uncontaminated" definition, even though DOE/NNSA and LANL believe all remedial actions necessary to address the known contamination on this tract, and allow its unrestricted transfer, have been completed according to the requirements of PL 105-119. Because Tract A-10 is not "uncontaminated," CERCLA Section 120(h)(4) is not applicable.

1.4.1 Adjacent Properties with Known or Suspected Releases

SWMU 21-029 and Consolidated Unit 21-021-99 are located immediately west of the A-5-3 tract. The remainder of the DP Canyon PRS, AOC C-00-021 is located directly west (upgradient) of the A-5-3 tract. See LANL 2004 for the history of use, site investigation and remediation activities. The southern boundary of Tract A-5-3 is approximately 75 feet upslope from the canyon bottom, and the tract does not include the sediment in the floodplain that is known to contain residual radionuclides.

1.5 Preliminary Results from Surveys for Residual Contamination

Figure 2 shows soil sampling locations for DP canyon taken in 2013. From these, a subset of samples nearest the A-5-3 tract was selected to be representative of the tract. Table 1 provides the soil concentration data from these samples, summary statistics, regional background levels, and reference threshold concentrations derived for residential and recreational use. Included in this data set is a sample taken from the contaminated sediment (#21-107), which elevates the mean and the standard deviation for the measurements. Using the sediement soil, the results show that the soil concentrations are above background levels for Am-241, Cs-137, Pu-238 and Pu-239. However, all preliminary measurements are significantly below all SALs for each of these radionuclides.

1.6 Conclusions regarding the classification of Tract A-5-3 relative to potential for residual radioactive contamination

There are properties adjacent or near to Tract A-5-3 that are either contaminated or have emitted radionuclides historically, and some LANL impact to the tract is possible (LANL 2004). The level of this impact is likely small as suggested by the data from the two preliminary soil samples taken within the tract (21-110 and 21-111), which were near background levels (Table 1). Thus, low-levels of residual contamination potentially exist on A-5-3 from activities conducted by LANL in nearby areas starting from the late 1940s; however, soil concentrations of radionuclides in soil from measurements shown in Table 1 and other past measurements in DP Canyon suggest that general levels are likely to be below all SALs, regardless of land use. Thus, DOE/NNSA believes no additional remedial activities are needed on the A-5-3 tract. Based on this assessment, the A-5-3 tract qualifies as a Class 3 area under MARSSIM (i.e., potentially impacted with concentrations of residual radioactive material in soils elevated, but likely to be significantly below thresholds and near background levels (MARSSIM 2000).

2.0 Data Quality Objectives for Sampling and Analysis Plan

The sampling and analysis plan (SAP) for Tract A-5-3 follows the LANL (2012b) procedure EDA-QP-238, "Dose assessment data quality objectives for land transfers into the public domain."

2.1 Objective of the Sampling and Analysis Plan

The objective of this sampling and analysis plan is to confirm, within the stated statistical confidence limits, that the mean levels of potential radioactive residual contamination in soils in the tract A-5-3 are documented, in appropriate units, and are below the 15 mrem yr^{-1} Screening Action Levels (SALs), as derived in LANL (2012) for the radionuclides of concern are provided in Table 1. **These and other SALs are used by LANL as preapproved Authorization Limits (ALs), as required in DOE Order 458.1 (section 2.k.(6)(f)2 in the contractors Requirements Document), and are identified as ALs in the rest of this SAP with regards to statistical decisions.** The entire tract was divided into two sub regions for sampling. The northern region, along the mesa top and near East Road, will be evaluated for residential use and the southern region of Tract A-5-3 will be evaluated for recreational use.

2.2 Decision identification

The principle study question is: Does the residual radioactive contamination exceed ALs for the either the residential exposure scenario (northern portion) or the recreational exposure scenario (southern portion)? The decision alternatives are:

- If results from the soil radioactive contamination measurements are at or above the AL (collectively), the site is not a candidate for land transfer.
- If results from the soil radioactive contamination measurements are below the AL (collectively), the site is a candidate for land transfer.

2.3 Inputs into the Decision

The assumed near-term future land use and exposure pathway assumes recreational use for A-5-3 South, and residential for A-5-3 North. ALs used for all the radionuclides analyzed for and the respective residential SAL is provided in Table 1, and the derivation of the SALs is provided in LANL (2012). The 15 mrem yr^{-1} SALs used in this analysis were calculated using RESRAD (RESRAD 2001).

Data to be used in the analysis include preliminary surface soil concentration measurements in (Table 1), which were used in the development of the Sampling and Analysis Plan. The unity rule will be applied because there are multiple radionuclides in the analysis. The formula used in for the unity rule is:

$$\frac{C_1}{AL_1} + \frac{C_2}{AL_2} + \frac{C_3}{AL_3} \ldots\ldots \frac{C_n}{AL_n} \leq 1 \qquad \text{(eqn. 1)}$$

where $C_{1\text{-}n}$ and $AL_{1\text{-}n}$ are the upper-bound estimates of the mean concentrations for radionuclides (e.g., upper 95% values) and Authorized Levels 1 through n, respectively.

2.4 Study Boundaries

The study is limited to Tract A-5-3, as identified in Figure 1. As concluded from historical information and previous sediment sampling, the list of radionculides in the analysis include Am-241, Cs-137, H-3, Pu-239, Pu-238, Sr-90, U-234, U235, and U-238. Individual doses are evaluated out to 1000 years.

2.5 Decision Rule

The decision rule is based on the null hypothesis that the mean residual contamination levels in soil and/or sediment in the northern and southern portions of the Tract A-5-3 combined over all radionuclides is above the AL and likely to result in an all pathway radiation dose to the critical receptor above 15 mrem yr^{-1}. The alternative hypothesis is that the mean residual contamination levels in soil and/or sediment in Tract A-5-3 combined over all radionuclides is below the AL and not likely to result in an all pathway radiation dose to the critical receptor above 15 mrem yr^{-1}. The northern and southern portions of A-5-3 will be analyzed individually because of differing land use and SALs thresholds.

2.6 Limits on Decision Errors

The acceptable statistical errors for this analysis are that Type I error (i.e., conclude contamination levels at site are < AL when in fact it is > AL) has a probability of $p < 0.05$; and the Type II error is (i.e., conclude soil contamination level is > AL when in fact it is < AL) has a probability of $p < 0.1$. Normality of the distribution for the preliminary data is not assumed.

2.7 Optimization of Design Process

The survey design is optimized by analyzing historical data. Specifically, there is no evidence of radiological operations in Tract A-5-3 with minimal impact from surrounding LANL operations, and the preliminary sediment data support this conclusion. Thus, the entire tract will be treated as a Class 3 area optimizing the number of required sample locations.

2.8 Statistically-Based Evaluation for Number of Samples Required using MARSSIM

Google Earth was used to download a map of the Tract A-5-3 area, which was then incorporated into Visual Sampling Plan (VSP) software (Matzke et al. 2010). The approximate boundary of the A-5-3 tract within was then delineated as a sampling area (Figures 1 and 3). The MARSSIM application within VSP was then used to determine the statistically-based sampling plan. The preliminary sampling data in Table 1 was used to determine the standard deviations needed for calculating the needed number of samples for each of the identified radionuclides. The sampling locations were randomly determined.

2.9 Instrumentation and Measurement Quality Objectives

The main objectives are to determine appropriate analysis technique for each radionuclide and ensure Measurement Quality Objectives are satisfied. One should be confident that the measurement results are valid and appropriate for the decisions being made.

2.9.1 Measurement Quality Objectives:

- Detection Capability: Minimum Detection Concentration (MDC) should be below the MARSSIM defined Lower Bound of the Gray Region (LBGR).
- The degree of measurement uncertainty (combined precision and bias) should be reported and the level reasonable relative to the needed accuracy of the decision and accounted for in the statistical analysis.
- Range of the instrument and measurement technique should be appropriate for the concentrations expected.
- The instrument and measurement technique should be specific for the radionuclide(s) being measured. Specificity is the ability of the measurement method to measure the radionuclide of concern in the presence of interferences.
- For field instruments, the instrument should be rugged enough to consistently provide reliable measurements. However, in this case, all samples will be analyzed in the laboratory.

2.9.2 Procedures used to meet these measurement quality objectives:

1) Collection of valid soil sample appropriate for the dose assessment,
    a. Sampling of soil will be done using LANL (2012a) procedure SOP-5132 "Collection of soil and vegetation samples for the environmental surveillance program." These are surface soil samples appropriate for the deposition pathway and the exposure scenario (i.e., top 5 cm). Subsurface soil samples are not required as depositions would be to surfaces with little migration to deeper soil expected.
    b. Additional quality assurance for the collection of the samples is provided through LANL (2008) procedure QAPP-0001 "Quality and assurance project plan for the soils, foodstuffs, and non foodstuff biota monitoring project."
2) Soil sample analysis using appropriate EPA approved analytical procedures for each radionuclide. The following will be used by the independent laboratory:
    a. Environmental Measurements Laboratory (EML). **The procedures manual of the Environmental Measurements Laboratory**. Report HASL-300; 1997. Radionuclide specific procedures for the radionuclides of Am-241, Pu-239 and U-238 are provided in EML (EML 1997).
    b. Environmental Protection Agency (EPA). **Method 901.1 - Gamma Emitting Radionuclides in Drinking Water***: Prescribed Procedures for Measurement of Radioactivity in Drinking Water*, EPA 600/4-80-032, prepared by EPA's Environmental Monitoring and Support Laboratory, August 1980 (EPA 1980). Available from NTIS, document no. PB 80-224744.

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d. Environmental Protection Agency (EPA). **Method 906.0 - Tritium in Drinking Water***: Prescribed Procedures for Measurement of Radioactivity in Drinking Water*, EPA 600/4-80-032, prepared by EPA's Environmental Monitoring and Support Laboratory, August 1980 (EPA 1980). Available from U.S. Department of Commerce, National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161, document no. PB 80-224744.

After the measurements are completed, the laboratory results in units equivalent to the ALs will be evaluated with respect to the MQOs, as stated above.

2.10 Statistical Evaluation of the Survey Results

All the applicable data that has passed the MQO evaluation will be used to determine the upper-bound estimate of the mean for soil concentrations (generally, the 95% value) for each radionuclide. The EPA software ProUCL (EPA 2010) will be used to determine this value. The statistical decision as to whether the residual soil contamination levels (i.e., the 95% UCLs) are below the authorized limits will be evaluated using the following criteria. All analyses and results will be documented.

Decision Criteria:

1) If all samples are ≤ residential (north portion) or recreational (south portion) AL, then no further action is required and the sites pass the criteria for residential/recreational occupation. No further actions are needed.

2) If all samples or the UCL are > the appropriate ALs, then the site is not a candidate for release and site remediation is needed followed by resampling before it can be released.

3) If the UCLs are below the ALs but some individual measurements are above the ALs, then statistical analysis is needed. Generally, non-parametric statistical approaches are used to evaluate the null hypothesis. If contamination is present in background, the Wilcoxon Rank Sum test is suggested, and if contamination is not present in background or very low relative to the AL, use the Sign Test. For Tract A-5-3, the Sign Test will be used with a $p < 0.05$ decision threshold for significance. See MARSSIM chapter 8 for details and examples.

4) Alternatively, one could confirm that the ratio of the upper-confidence level (UCL) of the average concentration divided by the AL and the sum of hot spot activity ratios do not exceed 1, as show in Equation 2.

$$\frac{\overline{C}_{UCL}}{C_{AL}} + \sum_{i=1}^{n} \frac{C_{i,C>AL}}{C_{AL} * AF} \leq 1 \qquad \text{(eqn. 2)}$$

Here $\overline{C}_{UCL}$ is the 95% upper bound estimate of the concentration mean, C_{AL} is the resident AL (15 mrem yr^{-1}), $C_{i,c>AL}$ is the sample concentration for a single sample above the AL (i.e., has elevated measured concentrations), and *AF* is the Area Factor [ratio of effective dose calculated for area of contamination normalized to effective dose calculated for 10,000 m^2 (RESRAD default)]. If value in eqn. 2 is > 1, the site is a candidate for further characterization of the nature and extent of the contamination, remediation of the site, follow up confirmatory sampling, and reanalysis against the decision criteria in this section. Area Factors are dependent on the exposure scenario and should be calculated individually.

5) If there are multiple radionuclides (*i*) being evaluated in a sampling unit, the sum of the ratios should be less than one, as shown in eqn. 1.

3.0 Results of the Analysis for Sampling Number and Locations

The specific details of the analysis using MARSSIM and the results are provided in Attachment 1 of this report. Results showed that approximately 24 randomly-sited samples were needed within the Tract A-5-3 and the approximate locations are drawn on Figure 2. Locations were randomly selected using a quasi-random number generator for x and y coordinates (Matzke et al. 2010). The specific statistical parameter values, analysis, results, and approximate coordinates for the randomly selected sampling locations are provided in the summary report (Attachment1).

4.0 REFERENCES

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4.1 HISTORICAL RECORDS AND OTHER PERTINENT DOCUMENTS

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Figure 1. Map of Tract A-5-3 in relation to Tract A-5-2 and East Road is shown in 1(a). The A-5-3 Tract in Figure 1(a) is highlighted in green and does not include the DP Canyon floodplain. Figure 1(b) is an orthoimage map showing the tract in relation to State Road 502 and businesses across the highway.

(a) (b)

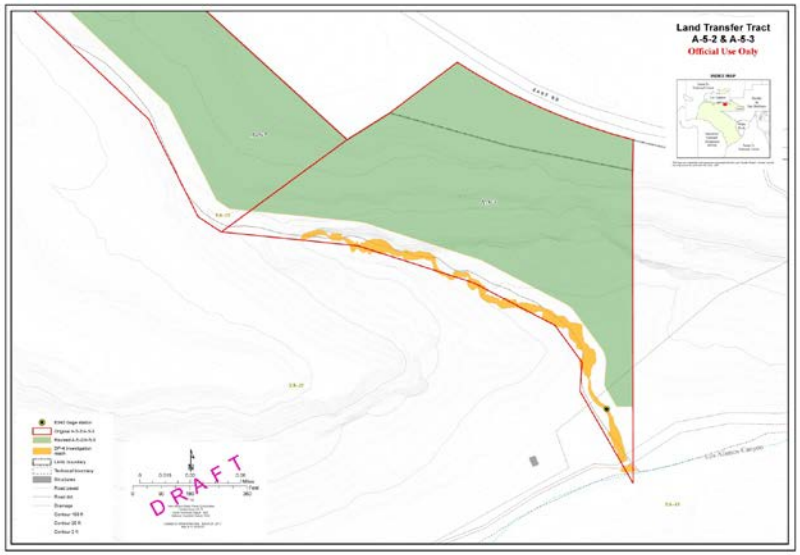

Figure 2. Location of soil samples taken in DP Canyon. Sample results from 21-104, 105, 106, 107, 110, 111, and 21-112 were used for the preliminary assessment for residual contamination for Tract A-5-3. See Table 1 for these results.

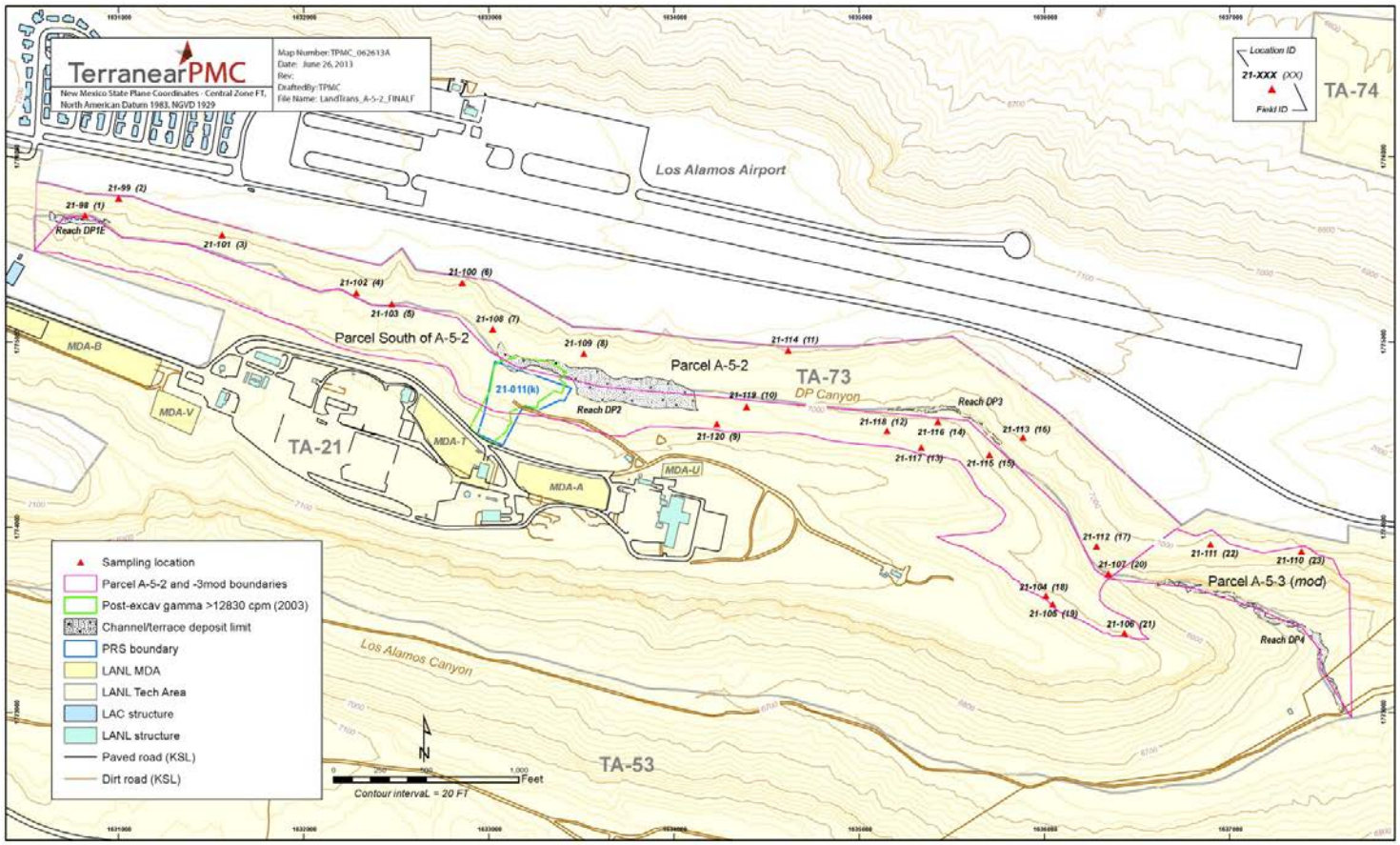

Figure 3. Approximate sampling locations in the northern and southern portions of Tract A-5-3 based on a MARSSIM-like sampling protocol.

Table 1. Preliminary survey results used for MARSSIM-based development of the sampling plan far Tract-A-5-3.

LOCATION_ID	Am-241	Co-60	Cs-137	H-3	Pu-238	Pu-239/240	Sr-90	U-234	U-235	U-238
21-104	0.011	-0.001	0.963	0.805	0.006	0.267	-0.002	0.814	0.016	0.93
21-105	0.162	0.003	0.765	-2.344	0.003	0.194	0.303	0.95	0.028	0.922
21-106	0.026	-0.005	0.166	-2.281	-0.006	0.045	-0.067	0.731	0	0.702
21-107	4.613	0	13.668	-0.869	0.416	2.345	3.817	1.278	0.061	0.813
21-110	0.026	-0.007	0.05	-0.709	0.008	0.025	0.224	0.583	0.026	0.63
21-111	0.27	0.002	0.459	-1.236	0.014	0.037	0.313	0.607	0.015	0.766
21-112	0.018	-0.007	0.202	-0.908	0.005	0.046	0.284	0.64	0.024	0.878
Mean	*0.732*	*-0.002*	*2.325*	*-1.077*	*0.064*	*0.423*	*0.696*	*0.800*	*0.024*	*0.806*
Median	*0.026*	*-0.001*	*0.459*	*-0.908*	*0.006*	*0.046*	*0.284*	*0.731*	*0.024*	*0.813*
SD	*1.714*	*0.004*	*5.013*	*1.067*	*0.155*	*0.853*	*1.385*	*0.247*	*0.019*	*0.114*
BKG	0.013		1.65	0.08	0.023	0.054	1.31	2.59	0.2	2.29
15 mrem/yr residental SAL	*49*	*1.5*	*6.7*	*510*	*50*	*48*	*9*	*160*	*23*	*92*
15 mrem/yr recreational SAL	*890*	*46*	*210*	*430000*	*850*	*770*	*3200*	*2300*	*570*	*1700*

Attachment 1

Random sampling locations for comparing a median with a fixed threshold (nonparametric - MARSSIM) for Tract A-5-3 (Northern and Southern portions)

Summary
This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed. A figure that shows sampling locations in the field and a table that lists sampling location coordinates are also provided below.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean or median to a fixed threshold
Type of Sampling Design	Nonparametric
Sample Placement (Location) in the Field	Simple random sampling
Working (Null) Hypothesis	The median(mean) value at the site exceeds the threshold
Formula for calculating number of sampling locations	Sign Test - MARSSIM version
Calculated total number of samples	12
Number of samples on map [a]	24
Number of selected sample areas [b]	2
Specified sampling area [c]	47949.59 m^2

[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.
[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.
[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.

Area: A-5-3 North					
X Coord	Y Coord	Label	Value	Type	Historical
386193.5872	3970937.3029			Random	
386224.0230	3970882.6212			Random	
386163.1514	3970923.6324			Random	
386208.8051	3970900.8484			Random	
386147.9335	3970941.8597			Random	
386269.6766	3970873.5076			Random	
386117.4978	3970914.5188			Random	
386178.3693	3970887.1780			Random	
386231.6319	3970906.9242			Random	
386170.7604	3970947.9354			Random	
386292.5035	3970879.5834			Random	
386094.6709	3970920.5946			Random	

Area: A-5-3 South					
X Coord	Y Coord	Label	Value	Type	Historical
386175.7466	3970815.2973			Random	
386082.8261	3970908.6480			Random	
386268.6671	3970642.4256			Random	
386152.5165	3970829.1270			Random	
386245.4370	3970766.8932			Random	
386013.1357	3970860.2439			Random	
386047.9809	3970839.4993			Random	
386187.3617	3970870.6162			Random	
386280.2822	3970808.3824			Random	
386257.0521	3970849.8716			Random	

386210.5918	3970787.6378			Random	
386117.6713	3970880.9885			Random	

Primary Sampling Objective
The primary purpose of sampling at this site is to compare a site median or mean value with a fixed threshold. The working hypothesis (or 'null' hypothesis) is that the median(mean) value at the site is equal to or exceeds the threshold. The alternative hypothesis is that the median(mean) value is less than the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative one, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach
A nonparametric random sampling approach was used to determine the number of samples and to specify sampling locations. A nonparametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that typical parametric assumptions may not be true.

Both parametric and non-parametric equations rely on assumptions about the population. Typically, however, non-parametric equations require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than if a non-parametric equation was used.

Locating the sample points randomly provides data that are separated by many distances, whereas systematic samples are all equidistant apart. Therefore, random sampling provides more information about the spatial structure of the potential contamination than systematic sampling does. As with systematic sampling, random sampling also provides information regarding the mean value, but there is the possibility that areas of the site will not be represented with the same frequency as if uniform grid sampling were performed.

Number of Total Samples: Calculation Equation and Inputs
The equation used to calculate the number of samples is based on a Sign test (see PNNL 13450 for discussion). For this site, the null hypothesis is rejected in favor of the alternative one if the median(mean) is sufficiently smaller than the threshold. The number of samples to collect is calculated so that if the inputs to the equation are true, the calculated number of samples will cause the null hypothesis to be rejected.

The formula used to calculate the number of samples is:

$$n = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{4(SignP - 0.5)^2}$$

where

$$SignP = \Phi\left(\frac{\Delta}{s_{total}}\right)$$

$\Phi(z)$ is the cumulative standard normal distribution on $(-\infty,z)$ (see PNNL-13450 for details),
n is the number of samples,
S_{total} is the estimated standard deviation of the measured values including analytical error,
Δ is the width of the gray region,
α is the acceptable probability of incorrectly concluding the site median(mean) is less than the threshold,
β is the acceptable probability of incorrectly concluding the site median(mean) exceeds the threshold,

$Z_{1-\alpha}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is 1-α,

$Z_{1-\beta}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is 1-β.

Note: MARSSIM suggests that the number of samples should be increased by at least 20% to account for missing or unusable data and uncertainty in the calculated value of n. VSP allows a user-supplied percent overage as discussed in MARSSIM (EPA 2000, p. 5-33).

The values of these inputs that result in the calculated number of sampling locations are:

Analyte	n[a]	Parameter					
		S	Δ	α	β	$Z_{1-\alpha}$ [b]	$Z_{1-\beta}$ [c]
Am-241	12	1.7 pCi/g	3.4 pCi/g	0.05	0.1	1.64485	1.28155
Cs-137	12	5 pCi/g	10 pCi/g	0.05	0.1	1.64485	1.28155
Pu-238	12	0.155 pCi/g	0.3 pCi/g	0.05	0.1	1.64485	1.28155
Pu-239	11	0.85 pCi/g	769 pCi/g	0.05	0.1	1.64485	1.28155
	0						

[a] The final number of samples has been increased by the MARSSIM Overage of 20%.
[b] This value is automatically calculated by VSP based upon the user defined value of α.
[c] This value is automatically calculated by VSP based upon the user defined value of β.

Statistical Assumptions

The assumptions associated with the formulas for computing the number of samples are:

1. the computed sign test statistic is normally distributed,
2. the variance estimate, S^2, is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected randomly.

The first three assumptions will be assessed in a post data collection analysis. The last assumption is valid because the sample locations were selected using a random process.

Sensitivity Analysis

The sensitivity of the calculation of number of samples was explored by varying the standard deviation, lower bound of gray region (% of action level), beta (%), probability of mistakenly concluding that μ > action level and alpha (%), probability of mistakenly concluding that μ < action level. The following table shows the results of this analysis.

Number of Samples							
AL=770		α=5		α=10		α=15	
		s=1.7	s=0.85	s=1.7	s=0.85	s=1.7	s=0.85
LBGR=90	β=5	14	14	11	11	10	10
	β=10	11	11	9	9	8	8
	β=15	10	10	8	8	6	6
LBGR=80	β=5	14	14	11	11	10	10
	β=10	11	11	9	9	8	8
	β=15	10	10	8	8	6	6
LBGR=70	β=5	14	14	11	11	10	10
	β=10	11	11	9	9	8	8
	β=15	10	10	8	8	6	6

s = Standard Deviation
LBGR = Lower Bound of Gray Region (% of Action Level)
β = Beta (%), Probability of mistakenly concluding that μ > action level
α = Alpha (%), Probability of mistakenly concluding that μ < action level
AL = Action Level (Threshold)

Recommended Data Analysis Activities

Post data collection activities generally follow those outlined in EPA's Guidance for Data Quality Assessment (EPA, 2000). The data analysts will become familiar with the context of the problem and goals for data collection and assessment. The data will be verified and validated before being subjected to statistical or other analyses. Graphical and analytical tools will be used to verify to the extent possible the assumptions of any statistical analyses that are performed as well as to achieve a general understanding of the data. The data will be assessed to determine whether they are adequate in both quality and quantity to support the primary objective of sampling.

Because the primary objective for sampling for this site is to compare the site median(mean) value with a threshold value, the data will be assessed in this context. Assuming the data are adequate, at least one statistical test will be done to perform a comparison between the data and the threshold of interest. Results of the exploratory and quantitative assessments of the data will be reported, along with conclusions that may be supported by them.